TITLE: Spinal Disease in Aviators and Its Relationship to G-Exposure, Age, Aircraft Seating Angle, Exercise and Other Lifestyle Factors

TITLE: Operational Issues of Aging Crewmembers [les Consequences operationnelles du vieillissement des equipages]

Spinal Disease in Aviators and Its Relationship to G-Exposure, Age, Aircraft Seating Angle, Exercise and Other Lifestyle Factors

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ABSTRACT: ***Introduction***: Repetitive G-exposures during high-performance (HP) flying have a potential to accelerate the progression of degenerative spinal disease in aviators so exposed. (This concern was identified as needing further research in the recently completed RTO Technical Report 4.) Critical in determining the significance of these G-exposures is the selection of a control group as similar as possible in all other respects to the HP aviators studied. ***Methods:*** An anonymous survey was conducted to better establish the nature and degree of G-related spinal symptoms and disease. HP aviators at Spangdahlem AB, Germany were compared with a control group of nonhigh-performance (NHP) aviators living at Ramstein AB, Germany. Based on an extensive survey these groups were matched for all relevant demographic and epidemiological factors. ***Results:*** 161 surveys were distributed and 79 returned for a return rate of 49%. No greater incidence of chronic spinal symptoms or disease in the neck or lower back were reported in the HP group as compared to the NHP group. However, a majority of HP aviators (54%) did report acute spinal symptoms, especially neck pain, temporally associated with pulling G's, occurring either during or shortly after sorties. Twenty percent of the total number of HP aviators responding reported that neck symptoms limited their flying performance, including pulling G's, checking 6, and performing air combat maneuvers. Despite the increased seat angle slant in the F-16 as compared to the F-15, no significant difference in neck symptoms or performance limitations were reported as a result. Both HP and NHP aviators were noted in general to have good exercise habits with minimal use of tobacco. However, moderate use of alcohol was noted in both groups. ***Conclusions:*** Spinal symptoms, especially neck pain, were a common problem associated with HP flying and frequently limited flying performance though did not appear to result in any increase in long-term morbidity in this relatively young, predominantly male, group of aviators.

Index Terms: Aerospace Medicine, Aircraft, Aviation, Health Surveys, Military Personnel, Questionnaires, Risk Factors, Spinal Diseases

INTRODUCTION

With the progressively increasing performance capabilities of high-performance aircraft over the last several decades, there has been concern for spinal symptoms and spinal disease in aviators flying these aircraft. This concern is well documented in the NATO RTO Technical Report "Cervical Spinal Injury from Repeated Exposures to Sustained Acceleration" published in February 1999 (RTO-TR-4 published by the Human Factors and Medicine Panel) and is an area identified as needing further research.

Literature Review

Numerous previous articles have reported anecdotal spinal injuries in aviators of high-performance aircraft (1,5,9). Andersen et al. reported a case of a flight surgeon flying in the back seat of an F-16B who was apparently caught unaware during an abrupt 8 G climbing turn and suffered a C5-6 ligamentous injury. Schall reported a case of a pilot incurring fractures of three cervical vertebrae when during defensive aerial combat maneuvering in an RF-4C, negative Gz forces resulted in the pilot's head impacting the canopy. Hämäläinen et al. reported 3 aviators with cervical disk bulges associated with severe in-flight neck pain during aerial combat maneuvers under high +Gz forces.

Other articles have reported surveys which have addressed various aspects of the problem of spinal pain in aviators (4,6,7,8,11,12). Kikukawa et al. studied 129 Japanese F-15 pilots of which 115 (89.1%) reported neck pain related to flying and 44 (34% of the total surveyed) reported that these symptoms adversely affected flight duty performance. Knudson et. al. compared neck pain and injury in pilots of F/A-18, A-7 and A-4 in the U.S. Navy and Marine Corps and found of the 148 aviators surveyed, 89 (60%) reported neck pain during flight with an increase in both frequency and severity of the pain with increased G loads. Hämäläinen et al. also investigated the physical and lifestyle factors correlated with +Gz neck pain in 27 student fighter pilots and found that an increase in frequency of overall muscle endurance training (not specifically neck muscle exercises) was statistically

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associated with a decrease in incidence of +Gz related neck pain. Newman surveyed 42 F/A-18 pilots to determine head positioning techniques which may reduce neck pain during +Gz exposure and found that 29 (69%) used protective strategies including pre-positioning the head and/or bracing the head against aircraft structures prior to +Gz exposure. Vanderbeek performed a prevalence study using an anonymous survey questionnaire sent to pilots of F-5, F-15 and F-16 aircraft. The survey found that higher aircraft performance was associated with an increased injury prevalence and that increased pilot age was associated with an increased prevalence of major injury. Yacovane et. al. performed a survey of naval aviators along with a 10 year review of the Naval Safety Center personal injury reports (1980-1990) and concluded that the most common G-associated injury pattern was simple cervical muscle strain which posed a potential threat to combat readiness, but otherwise G-exposure was not a major problem. The study also found evidence that muscle-strengthening exercises may be helpful in prevention.

Other studies have investigated more objective determinants of spinal changes and spinal disease (2,3). Hämäläinen et al. performed low field (0.1 tesla) cervical MRIs on 12 fighter pilots frequently exposed to high +Gz forces and on 11 controls (ground personnel) matched for age and sex. While 11 of the 12 +G exposed pilots reported a history of in-flight neck pain, the number of pilots and controls reporting neck pain unrelated to G exposure during the prior twelve months was comparable (9 of 12 pilots vs. 8 of 11 controls). Nonetheless, a slight increase in the occurrence and the degree of disk degeneration was found among the pilots, especially at the C3-4 intervertebral disk space. Burns, Loecker et al. analyzed the findings on high-field strength (1.5 tesla) MRIs performed on the entire spine of 22 asymptomatic centrifuge subjects and 19 age and sex-matched controls. A small (statistically non-significant) increase in spinal disk abnormalities was observed in the centrifuge-exposed subjects. Intra-reader and inter-reader variability in MRI interpretation was found to be considerable.

METHODS

A comprehensive questionnaire was developed to survey a representative group of high-performance (HP) aviators along with a comparison group of nonhigh-performance (NHP) aviators. The nonhigh-performance aviators were chosen as a control group because it was believed that with respect to both physical and lifestyle characteristics this group would be similar to the high-performance group of aviators with the single exception of G-exposure. It was critical to the study that the nonhigh-performance aviators had as similar a lifestyle as possible to the study group. An extensive questionnaire was devised not only to address the numerous research questions but also to establish the degree of similarity between the two groups. The study addressed the specific spinal symptoms which occurred, the circumstances, e.g., increased +Gz exposure, checking 6, etc., during which they occurred, the effects of the symptoms on aviator flying performance, preventive techniques employed to prevent the symptoms, the effectiveness of such techniques and the other lifestyle factors which may be associated with and possibly contributing to the spinal symptoms. Aviators were also queried about any medical history of more objective spinal disease. Of particular concern were the effects of any symptoms on limiting flying performance even if these symptoms did not produce objectively determinable spinal pathology. The survey was anonymous to maximize the yield of frank and candid answers.

Another concern addressed by the survey was the significance of the 30-degree backward seat angle of the F-16 as compared to the 13-degree angle of the F-15. This increased seat angle of the F-16 may result in increased neck flexion in order to allow the pilot to see forward and, thus, an increase in stress concentration in the lower cervical spine. Such an increase in stress concentration could result in both an increase in neck pain as well as an increase in objective spinal pathology in the region.

Survey questionnaires were sent to the flight surgeons at Spangdahlem AB and Ramstein AB in Germany for distribution to the aviators at those bases. The HP cohort consisted of 81 pilots assigned to fighter squadrons (22nd FS, 23rd FS and 53rd FS) at Spangdahlem AB, Germany. The NHP cohort, i.e., flyers of tankers, transports and bombers, consisted of aircrew assigned to airlift squadrons (37th AS, 75th AS and 76th AS) at Ramstein AB, Germany. The aircrew were predominantly rated aviators, though several FCIII aircrew (loadmasters, aero-evacuation technicians and flight engineers, etc.) were also included. The questionnaires were distributed by the squadron flight surgeons for anonymous return by the participants upon completion. Approval for the study was obtained from the Advisory Committee for Human Experimentation (ACHE) at Brooks AFB and a survey control number (USAF SCN 9646) was obtained from Air Force Manpower and Personnel Center Survey Control Branch, Randolph AFB, TX.

Pearson's chi-square statistics for two-way frequency tables were used to make statistical comparisons. Kendall's tau b statistic was used for tests of statistically significant correlations.

RESULTS

Demographics

Of the total of 81 questionnaires distributed to the HP cohort at Spangdahlem AB, 35 questionnaires were

returned for a response rate of 43%. The specific return rates for the squadrons were 15 of 35 (43)% for the 22nd Fighter Squadron and 5 out of 23 (22%) for the 23rd Fighter Squadron, both of which fly F-16s and 12 out of 23 (52%) for the 53rd Fighter Squadron which flies F-15s. Thirty-five of the respondents were male and one of the respondents was female.

Of the total of 80 questionnaires distributed to the NHP cohort at Ramstein AB, 44 were returned for a 55% response rate. The respondents consisted of 35 pilots (10 in the C-9, 9 in the C-21, 8 in the C-130, 7 in the C-20 and 1 in the C-121), 4 flight surgeons (2 in the C-9, 1 in the C-130 and 1 in the C-20), 2 flight engineers (C-130), 2 aeromedical technicians (C-9) and 1 loadmaster (C-141). Thirty-nine of the respondents were male and 5 of the respondents were female (3 pilots, 1 flight engineer and 1 aeromedical technician).

The demographics for all aviators who responded are shown in Table 1. A comparison of the demographics for HP and NHP aviators is shown in Table 2. The mean age for HP aviators was 32.6 vs. 30.5 years for NHP aviators. The height (70 vs. 69 in.) and weight (178 vs. 173 lbs.) were also similar. The total military flying time (TMFT) was similar (2034 vs. 1786 hours) though the time in the current aircraft was significantly higher for HP aviators (1028 vs. 593 hours). Not surprisingly, due to the nature of the missions, the average flying hours per month and the average hours per sortie significantly differed for the HP aviators and the NHP aviators (17.9 vs. 26.6 hours per month and 1.3 vs. 3.3 hours per sortie).

Table 1: Demographics (All Subjects)

Variable	Mean	Standard Deviation	Range
Age (years)	31.4	4.5	21-44
Height (inches)	70	4.2	50-75
Weight (pounds)	175	20.9	120-210
Total Military Flying Hours	2102	1192	150-5000
Flying Hours in Current Aircraft	776	598	30-2900
Flying Hours per Month	23	7.9	8-50
Average Sortie Length (hours)	2.4	1.6	1-8

Table 2: Demographics (High Performance vs. Non High Performance Subjects)

Variable	Mean	Standard Deviation	Range
Age (years)			
High Performance (HP)	32.6	4.0	26-42
Non High Performance (NHP)	30.5	4.7	21-44
Height (inches)			
HP	70	3.0	60-75
NHP	69	4.9	50-75
Weight (pounds)			
HP	178	17.0	145-210
NHP	173	23.2	120-210
Total Military Flying Hours			
HP	2034	1029	300-4200
NHP	1786	1306	150-5000
Flying Hours in Current Aircraft			
HP	1028	653	100-2900
NHP	593	484	30-2150
Flying Hours per Month			
HP	17.9	4.3	8-25
NHP	26.6	8.0	10-50
Average Sortie Length (hours)			
HP	1.3	0.13	1.0-1.5
NHP	3.3	1.73	1.0-8.0

A comparison of the demographics of the F-15 vs. the F-16 aviators responding are shown in Table 3. Comparing the statistics for the two groups one can see that all characteristics are quite similar with exception of a minor increase in the total military flying hours (2317 vs 1880 hours) and a minor increase in the flying hours in the current aircraft (1243 vs. 900 hours) for the F-15 group.

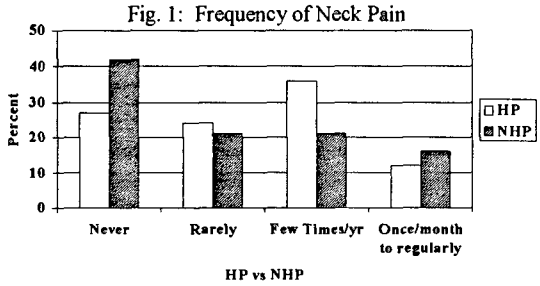
Table 3: Demographics (F-15 vs. F-16 Pilots)

Variable	Mean	Standard Deviation	Range
Age (years)			
F-15	34.1	3.8	28-40
F-16	31.8	4.1	26-72
Height (inches)			
F-15	69.8	3.9	60-75
F-16	70.4	2.4	66-75
Weight (pounds)			
F-15	181.7	13.2	160-205
F-16	175.3	18.8	145-210
Total Military Flying Hours			
F-15	2317	714	550-3200
F-16	1880	1152	300-4200
Flying Hours in Current Aircraft			
F-15	1243	803	150-2900
F-16	900	525	100-2200
Flying Hours per Month			
F-15	14.6	4.1	8-25
F-16	19.7	3.4	10-25
Average Sortie Length (hours)			
F-15	1.2	0.1	1.0-1.5
F-16	1.3	0.1	1.0-1.5

Chronic Neck and Low Back Symptoms

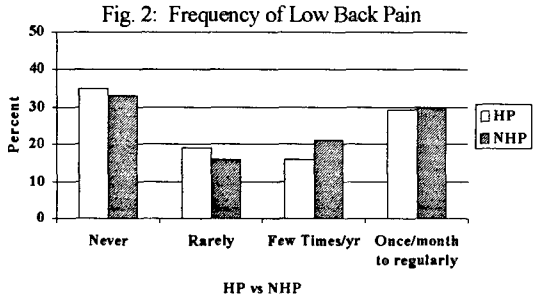
The frequency of neck pain for HP and NHP was compared as shown in Figure 1. For this analysis, 2 aviators were removed from the HP category and 1 was removed from the NHP category due to a history of previous neck injury. Twenty-seven percent of the HP aviators report never having neck pain, whereas, 42% of the NHP aviators report never having neck pain. However, this difference was mostly accounted for by the difference in neck pain occurring a few times/year (36% vs. 21%). In fact, fewer HP aviators report neck pain occurring once per month or more than did NHP aviators (12% vs 16%). An analysis of this data using the chi-square statistical method with 3 degrees of freedom resulted in a value of 3.042 for a probability 0.385, not deemed to be statistically significant. Thus no significant difference in reporting of chronic neck pain for the HP vs. NHP aviators was found. A power analysis for detecting a similar hypothetical two-fold difference in neck pain revealed that this study had a 75% chance of detecting this difference at the 0.05 level of statistical significance.

Fig. 1: Frequency of Neck Pain



The frequency of low back pain was compared for HP and NHP aviators as shown in Figure 2. In this case, 4 HP and 1 NHP aviator were removed from the analysis due to a history of previous low back injury. Of the 74 remaining (31 HP and 43 NHP), a chi-square analysis with 3 degrees of freedom resulted in a value of 0.371 for a probability of 0.946, not felt to be statistically significant. A power analysis for detecting a similar hypothetical two-fold difference in low back pain again revealed that this study had a 75% chance of detecting this difference at the 0.05 level of statistical significance.

Fig. 2: Frequency of Low Back Pain



Also, of interest was the difference in spinal pain reported for the F-15 and F-16 pilots. Of concern was the 30-degree backward slanting seat angle in the F16 vs. the 13-degree angle in the F-15. The F-16 seat angle may result in an increase in neck flexion and, potentially, an increase in stress concentration in the lower cervical region, particularly at the C5-6 and C6-7 intervertebral regions where herniated discs are quite common. In contrast, the increased seat angle in the F-16 could cause the seatback to absorb more axial +Gz load that would otherwise be transferred to the lumbar spine in a more vertical seatback. Thus, there is a potential for an increase in lumbar spinal pain in the F-15 where such a load transfer does not occur.

A comparison of neck symptoms for aviators in the F-15 and F-16 aircraft is shown in Figure 3. One F-15 and one F-16 aviator were removed from the analysis due to a history of neck injury prior to flying their current aircraft. The chi-square analysis using 3 degrees of freedom resulted in 0.938 for a probability of 0.816, again, not statistically significant. In this case, the limited size of each of these aviator groups resulted in a power for detecting a two-fold difference in symptoms of only 40%. Similarly, a comparison of the reporting of low back pain for the F-15 and F-16 aviators using chi-square and 3 degrees of freedom resulted in 1.638 for a probability of 0.651, not statistically significant. A comparison of the data is shown in Figure 4. Again, a significant limitation in this comparison was the power of the analysis, which was 40% for detecting a two-fold difference.

Fig. 3: Frequency of Neck Pain

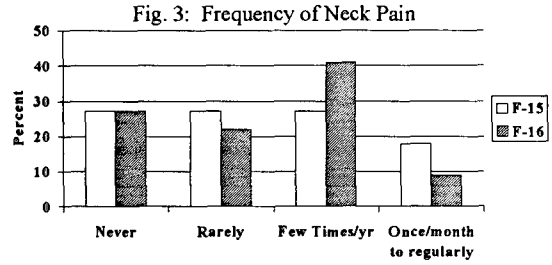
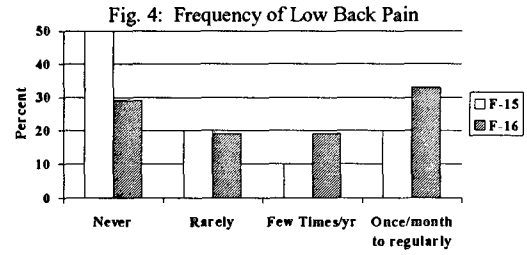


Fig. 4: Frequency of Low Back Pain

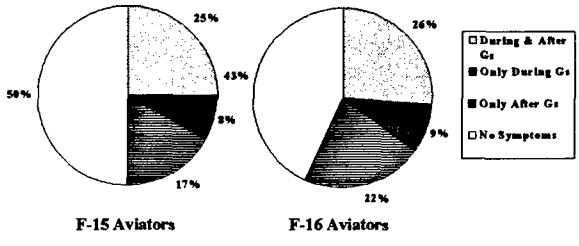


Acute Spinal Symptoms During and After G-Exposures

Despite the lack of a significant increase in reported neck pain unrelated to flying by HP aviators, many HP aviators did report neck pain temporally associated with G-exposures. Of the 35 HP pilots surveyed, 19 (54%) reported spinal symptoms occurring with

G-exposure, either during the exposure or shortly afterward. From the context of responses and associated comments the symptoms generally were neck pain and /or soreness. These positive respondents included 6 of the 12 (50%) F-15 pilots, three of whom had neck pain during and after G-exposures, one having neck pain just during the exposure and two reporting neck pain occurring only 2-8 hours afterward. Similarly, 13 of the 23 (57%) F-16 pilots reported G-related neck pain. Six of these pilots developed the symptoms during and after G-exposure, with 2 having neck pain just during G-exposure and another five having neck pain only 2-8 hours after exposure. As shown in Figure 5, the frequency of spinal symptoms in the F-15 and F-16 aircraft were, indeed, quite similar.

Fig. 5: Neck Pain or Soreness Associated with G-Exposure

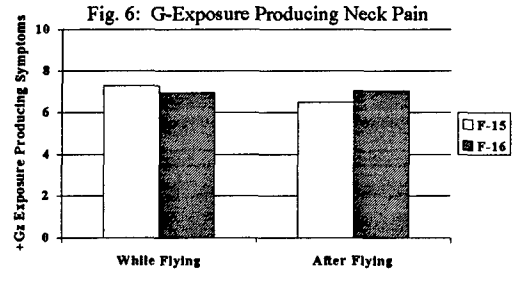


Most of the HP aviators reporting neck pain temporally associated with G-exposure wrote in specific causes such as "pulling G's, "BFM maneuvers", "turning head while pulling G's" and "head bent forward while pulling Gz's". For relief of symptoms, the majority of respondents reported that rest; heat and message; NSAIDS and sleep were beneficial. A few aviators specifically mentioned that reducing the amount of G-exposure was beneficial.

Of the 54 aviators commenting on techniques to prevent spinal symptoms (neck or lower back), almost all suggested some form of stretching or exercise as a means to prevent symptoms. Nineteen of the aviators referred to stretching that particular area of the body prior to flight. Twenty-two reported that general stretching exercises, especially those recommended by physical therapy, were helpful. Five reported that to prevent neck pain they pre-positioned their head prior to G exposures. Two relieved their neck pain by using pillows at night and two by improving posture. Three reported that nothing helps. (Some respondents provided more than one preventative technique.). For lower back pain, specifically, two aviators reported that using an increased number of lumbar supports while flying was helpful and one reported that lifting properly (unrelated to flying) was helpful. In summary, of the 54 aviators reporting techniques to prevent spinal symptoms, 40 (74%) specifically volunteered that some form of exercise, to include stretching, was helpful in preventing symptoms.

For those HP aviators reporting neck pain while flying, the mean G exposure at which symptoms of spinal pain occurred was 7.1 Gs (range 5-9) with a mean of 7.3 Gs (6-8) for the F-15 and a mean of 7.0 Gs (5-9) for the F-16 (Figure 6). The mean G exposure which lead to neck pain after flying for those HP pilots reporting this symptom was 6.9 Gs (5-9) with 6.5 Gs (5-8) for F-15 pilots reporting subsequent spinal pain and 7.1 Gs (5-9) for F-16 pilots reporting subsequent spinal pain. (One F-15 aviator reported that the G-exposure, which produced symptoms, depended on the positioning of his head.) With respect to the specific maneuvers producing spinal symptoms almost all of those responding specified checking 6 and/or rotating the head during G exposure, including basic fighter maneuvers (BFM) as contributing to neck symptoms in particular.

Fig. 6: G-Exposure Producing Neck Pain



Twenty-four of the 79 aviators (30%) sought medical attention of some form for spinal symptoms during their career. They consisted of 15 of the 35 (43%) HP aviators (5/12 or 42% of F-15 and 10/23 or 43% of the F-16 pilots) and 9 of the 44 (20%) NHP aviators. Every one of the 14 HP aviators who fully completed the survey question sought the initial medical care from their flight surgeon. In contrast, of the 9 NHP aviators seeking medical care, 3 (33%) sought the initial medical care from a provider other than their flight surgeon. This group consisted of one C130 pilot, one C21 pilot and one C9 pilot. Two of the three subsequently visited their flight surgeon for their symptoms. This small sample did not lend itself to a detailed statistical analysis. However, the findings do suggest that HP aviators are very compliant in using their flight surgeons for medical care.

For the 18 aviators completing information on the number of medical office visits required for spinal symptoms, the mean number of office visits was 3.7, with a mean of 1.5 visits to the flight surgeon and 2.2 visits to either chiropractors or other non-physician providers. Eleven aviators had spinal x-rays taken, all of which were essentially normal. (Two of these studies were interpreted as having "spinal misalignment" by a chiropractor.)

Six of the 35 HP aviators (1 F-15 and 5 F-16 pilots) reported having been grounded for spinal problems. In

contrast, only 2 of the NHP report having been grounded for spinal symptoms, both of whom had prior accidents - one being dropped from a hoist in survival school who had problems ever since and one aviator who had a traumatic cervical spinal fracture at age 22, apparently prior to entering uniform pilot training (UPT), which required spinal fusions.

Six of the 35 HP aviators (17%) reported loosing flying time annually due to spinal symptoms. The mean days lost per year was 5.5 days with a range of 2-14 days for the individuals reporting such annual groundings. Including those HP aviators not reporting annual groundings, the total group of 35 HP aviators' report loosing an average of 1 flying day per year due to spinal symptoms. In contrast, of the 44 NHP aviators, none reported loosing flying time annually due to spinal symptoms. Only two reported a history of previous grounding for spinal symptoms, both of whom had specific injuries unrelated to flying.

The age of onset of spinal symptoms was investigated. Seven of 12 F-15 aviators (58%), 11 of 23 F-16 aviators (48%) and 27 of 44 NHP aviators (61%) reported a history of having been bothered by spinal symptoms at some point in their life. The mean age of onset for the total group having symptoms was 25.6 years old (range 15-35). The mean age of onset was similar for each subgroup, 25.4 years for the F-15 pilots, 26.9 years for the F-16 pilots and 26.0 years for the NHP aviators.

Of concern was the possibility that spinal symptoms limited the flying performance of HP aviators. Of the 24 (of 35 total) HP aviators who reported neck symptoms, 7 (30% of those with symptoms) reported that these symptoms limited flying performance. For this group of 7 aviators, 3 (3/35 or 9%) reported limited the pulling of Gs, 5 reported limiting checking 6 and 4 reported limiting air combat maneuvers, particularly during BFMs, due to G-related spinal symptoms. Of the 17 HP aviators with neck symptoms who reported that flying performance was not limited, many volunteered comments such as "potential for hurting yourself while pulling Gs, but if careful, O.K" and "don't turn neck and be careful during high Gs" even though they specifically didn't report that the symptoms limited their flying performance. Thus, it appears that spinal symptoms significantly limit the flying performance of a significant portion of HP aviators, 20%(7/35) in this case.

Variation of Symptoms with Age and Total Military Flying Hours

Studies of correlations were performed to determine any association between cervical and lumbar symptoms and 1) age and 2) total military flying hours(TMTF). The later was used as an assessment of whether extensive exposure to high-performance flying resulted in an increase in degenerative spinal disease, and, consequently, an increase in spinal symptoms. Figures 7 and 8 illustrate the prevalence of reported cervical and lumbar spinal symptoms as a function of age. The NHP data is a measure of the effect of age alone, without the confounding influence of G exposures. In contrast, the HP data allows for the confounding effect of G exposures over time and, specifically, relates to symptoms in aviators in HP aircraft. Despite the minor upward trend in cervical symptoms with advancing age, particularly for HP aviators (Fig 7), statistical analysis revealed no significant correlation. Further evaluation was made of the power of the study. Due to the limited sample size, the estimate of the likelihood of detecting a 50% difference was only 20%. Thus, while there was no statistically significant correlation between neck pain and age in HP aviators, a trend was noted and likely would have achieved statistical significance if a larger sample size had been available.

Fig. 7: Age vs. Neck Pain

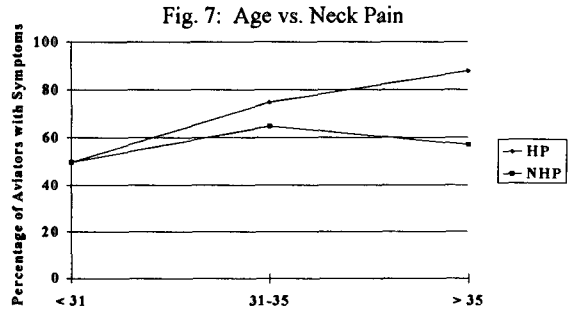
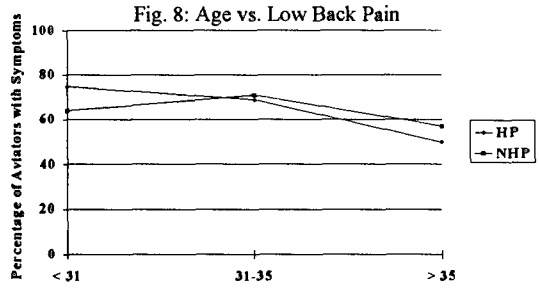


Fig. 8: Age vs. Low Back Pain



The relationships between the prevalence of cervical and lumbar spinal symptoms and TMTF are shown in Figures 9 and 10. TMTF was used to address the concern that repeated G exposures in HP aircraft may contribute to the progression of degenerative spinal disease and associated spinal symptoms. Again, no trend in increasing prevalence of spinal symptoms with increasing flying time was appreciated, suggesting that at least within the age group and range of flying time which this survey group represents, repeated G exposures do not result in a progression of symptomatic degenerative spinal disease.

Fig. 9: TMFH vs. Neck Pain

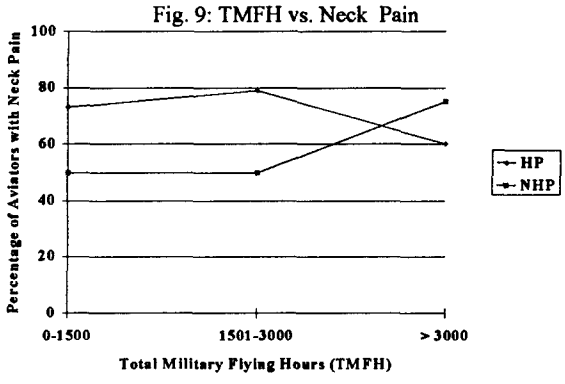
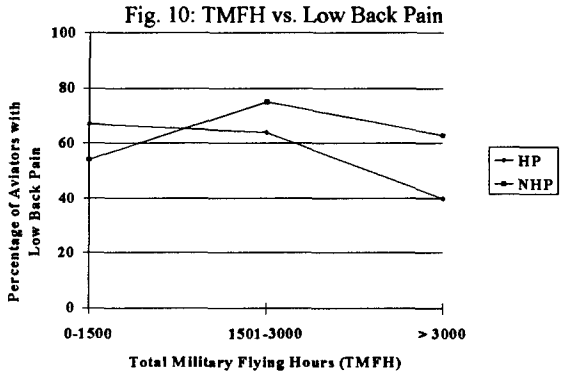


Fig. 10: TMFH vs. Low Back Pain



Exercise and Lifestyle Habits

Of the 78 aviators providing information on exercise, 74 (95%) reported performing some form of aerobic exercise at least once per week. Of the 71 aviators who specified the frequency of aerobic exercise, 44 of them (62%) performed aerobic activities at least 3 times per week. Thus, fully 59% (44/75) of the total group of respondents reported performing aerobic exercise at least 3 times per week.

With respect to HP aviators, 100% of those responding reported performing some form of exercise. 61% (20/33) of the HP aviators reported performing aerobic exercise at least 3 times per week, 21% (7/33) performing aerobic exercise 2 times per week, 15%(5/33) performing aerobic exercise once per week and 3% (1/33) performing only isometric exercise. 84%(28/34) of the HP aviators reported weightlifting at least once per week. Neck exercises, specifically, were performed at least once weekly by 50% (17/34) of HP pilots responding to the question. No significant difference in pattern of exercise was appreciated in comparing the F-15 and F-16 subgroups of HP aviators.

Of the 44 TTB aviators responding to the question regarding exercise, 93%(41/44) reported some form of exercise. Of the 42 providing information on the frequency of aerobic exercise, 60% (25/42) performed aerobic exercise at least 3 times per week, 21% performed aerobic exercise 2 times per week, 12% (3/42) performed aerobic exercise once per week and 7% (2/42) performing no aerobic exercise. In contrast to the 84% of HP aviators who weight lifted, 61% of the TTB aviator's weight lifted at least once per week. Only one of the 44 TTB aviators (2%) reported performing neck exercises, a 41-year-old C-20A pilot with a history of previous traumatic neck injury.

Eight of the aviators reported that specific exercises aggravated their spinal symptoms. 4 with neck pain (3 of who were HP aviators) reported that the use of weights aggravated their neck pain. Similarly, 5 with low back pain (2 of who were HP aviators) reported that the use of weights aggravated the condition. (One aviator had both neck and low back pain.) Two of the aviators with low back pain also reported that running aggravated their condition.

Another question addressed smoking habits. Of the 78 aviators responding to the question only 2 smoke (3%), both of who were flight engineers. Thus of the total of 73 rated aviators surveyed, not a single one reported smoking. A previous study by Dr.Vicky Voge observed a correlation between smoking and spinal symptoms (personal communication) but the low incidence of smoking in this study did not enable such an analysis.

Another question pertained to alcohol consumption. Of the 78 aviators responding to the question, 67 reported drinking. This consisted of 29 of 34 HP aviators (85%) and 38 of 44 TTB aviators (86%). The majority of aviators, 46 of 78 (59%), did not drink everyday. However, 32 of the 78 aviators responding (41%) had at least one drink per day. Five of the aviators (6%) reported consuming two drinks on average per day (one HP and four NHP pilots). None of the aviators reported consuming more than two drinks daily on a regular basis.

DISCUSSION

HP aviators reported significant neck pain associated with pulling G's, both during G exposure and for a few hours thereafter. Consistent with these reported acute symptoms, HP aviators as compared with the NHP aviators did have an increase in objective evidence of spinal symptoms including an increase in seeking medical care for these symptoms (43% vs. 20%), an increase in the annual rate of groundings (17% vs. 0% when excluding for a history of prior injury), and an increase in associated loss in annual flying time (1 vs. 0 days per year). However, there was no significant difference in reported neck or low back symptoms outside of the immediate effects of this G exposure. Similarly, in this relatively young group of aviators with a mean age of 31 and a mean total flying time of 2102 hours, there was no increase in objective pathology, such as abnormalities on x-rays, of which

the respondents were aware. . The onset of spinal symptoms in the subgroup of aviators reporting same was at the relatively young age of 26 years old and quite variable, ranging in age from 15-35 years old.

Within the HP group, comparing F-15 and F-16 aviators there was no significant difference in neck or low back pain. This suggests that the increased slant of the F-16 seat when compared with the F-15 seat is not a major problem with respect to spinal symptoms. However, the F-15 vs. F-16 comparisons were significantly limited by the size of these aviator subgroups such that a difference of two-fold or less in prevalence of symptoms was unlikely to be detected.

Importantly, neck pain tends to limit flying performance in the subset of HP aviators with such symptoms. Overall for the HP aviators, 54% had neck pain associated with flying, either during or shortly after sorties and was very similar for F-15 and F-16 aviators. For aviators with such symptoms, the mean G exposure producing such symptoms was 7.1 G's with a range of 5-9 G's and was very similar in both F-15's and F-16's. Specific flying activities reported as aggravating neck pain included BFMs, checking 6, head turning while pulling Gs and non-neutral head position while pulling G's, such as cervical flexion. Of the total of 35 HP aviators surveyed, 7 or 20% admitted to limiting flying maneuvers due to spinal symptoms. These maneuvers which were limited included pulling of Gs, checking 6 and/or air combat maneuvers, especially BFMs, due particularly to neck pain.

The HP aviators found that stretching, neck exercises and pre-positioning one's head prior to pulling G's are all effective in reducing G-associated neck pain. Lumbar supports tend to prevent low back pain in those aviators having such symptoms. For relief of neck or lower back pain, rest, heat and message, NSAIDS and sleep were found to be beneficial.

The reason for the finding of a somewhat lower compliance rate in flight surgeon use by NHP aviators is unknown and may be due to chance only. As the C-130 squadron at Ramstein has a squadron medical element (SME) similar to that of the fighter squadron groups at Spangdahlem, the lack of an SME is not the cause of this observation.

The exercise habits of this group of aviators is commendable, with 59% of the total performing aerobic exercise at least 3 times per week. Fully 95% of the aviators reported aerobic exercise at least once per week. This frequency of aerobic activity was quite similar for the HP and NHP aviators. The slight increase in weightlifting (84% Vs 61%) in HP aviators as compared to NHP aviators is consistent with the common use of weight training to enhance G-tolerance. The increase use of neck exercises by HP vs. NHP aviators support the commonly held belief that for a majority of HP aviators such exercise are helpful in preventing G-related neck symptoms. A minority of aviators with neck or low back symptoms reported that exercises using weight on that particular portion of the spine aggravated the condition. Also, running was reported as aggravating low back pain in two aviators with this symptom. Other health habits were quite impressive with none of the rated aviators surveyed smoking. In contrast, alcohol use was common within all subgroups of aviators with a significant minority drinking one or more drinks daily.

There were significant limitations in this study. First of all the sample size was small with a total of 79 respondents. This low n limited the ability of the study to detect small differences at statistically significant levels. Also, the 49% overall return resulted in an additional concern for potential systematic bias. For example, aviators with significant spinal symptoms may be more likely (or less likely) to complete the survey. Nonetheless, it is reasonable to assume that a similar pattern of behavior would occur for all aviators, whether HP or NHP. Therefore, while there is some concern regarding the values for absolute prevalence of symptoms, the comparative rates in different groups are felt to be valid.

Finally, the study fails to adequately address the effects of longer term G exposure. This issue would be better investigated by studies of older aviators more likely to have such symptoms or to have objectively determinable disease. This concern may be further addressed in a separate study including older aviators.

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DISCLAIMER

The opinions expressed in this paper are solely those of the author and do not necessarily reflect Department of Defense or Department of the USAF policy.

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